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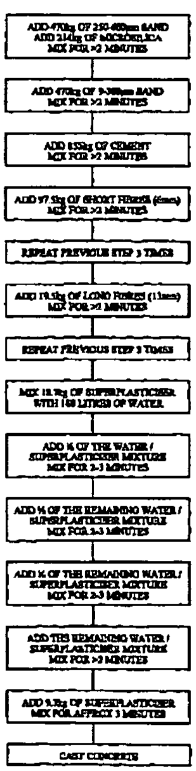
(54) Title: CEMENTITIOUS MIXTURES



(57) **Abstract:** A method of producing a cementitious mixture initially comprises thoroughly dry mixing the coarsest constituent of the mixture with the finest: this process is repeated until all of the sand, microsilica and cement has been added. In this manner a very even distribution of the different sized particles is achieved, since the voids between adjacent larger particles are filled with smaller particles and thus the produced concrete has a high strength. Following the dry mixing, water and superplasticiser is added. Less water than is conventionally used is required since the mixture is more densely packed. In order to further strengthen the mixture and to greatly enhance its energy absorption capacity, reinforcing fibres having different lengths may be added prior to adding the water and following mixing of the granular materials. The fibres are added by placing them on an apertured surface which is agitated to cause the fibres to fall through the apertures in a random orientation.

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European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Cementitious Mixtures

This invention relates to cementitious mixtures and more particularly but not solely to fibre-reinforced concrete mixtures.

Concrete is a well known cementitious mixture which has a wide variety of applications. However, a limitation of concrete is that its pore structure, permeability, tensile strength and energy-absorption capacity are not always optimised, thereby preventing its use as a strengthening material, for example in strengthening bridgework.

One of the reasons for this is that the ratio of water to cement and aggregate is high. Another reason for this is that the voids between adjacent particles of aggregates are large and are merely filled with hydrated cement: this inherently leads to weakness.

We have now devised a method of producing a cementitious product which alleviates the above-mentioned problems.

In accordance with this invention, there is provided a method of producing a cementitious mixture comprising adding granular materials having a range of particle sizes to a mixing vessel and thoroughly mixing the materials prior to adding water.

We have found that by thoroughly mixing the granular materials prior to adding water that a very even distribution of the different sized particles is achieved. Thus, the voids between adjacent larger particles are filled with smaller particles thereby avoiding the above-mentioned problems. Less water is required since the mixture is more densely packed.

Preferably the granular materials having the finest and coarsest particle sizes are initially added to the mixing vessel and thoroughly mixed, preferably for at least 2 minutes.

Preferably the granular material having the next coarsest particle size is then added to the aforementioned mixture and mixed, preferably for at least 2 minutes.

Preferably the granular material having the next finest particle is then added to the aforementioned mixture and mixed, preferably for at least 2 minutes.

The processes of adding the next coarsest then the next finest is repeated until all of the granular materials have been added.

In order to further strengthen the mixture and to greatly enhance its energy absorption capacity, reinforcing fibres are preferably added to the mixing vessel prior to adding the water and preferably following mixing of the granular materials.

Preferably fibres having different lengths are added, with the shorter fibres preferably being added first.

Preferably the fibres are mixed with the granular material following the addition of each different length of fibre.

Preferably the fibres are added by placing them on an apertured surface and agitating the surface to cause the fibres to fall through the apertures: we have found that this method separates the fibres and helps to avoid clumping of the fibres in the mixture.

Preferably a plurality of quantities of water are added to the mixture, with the mixture being mixed following the addition of each quantity.

Preferably the volume of water added with each quantity decreases.

Preferably the mixture is mixed for at least 2 minutes following the addition of each quantity.

Preferably the water contains a plasticiser or superplasticiser.

Preferably undiluted plasticiser or superplasticiser is added following addition of the water.

As mentioned hereinbefore, it can be a problem to separate strengthening fibres, since the fibres have a tendency to clump together because of their electrostatic charge.

Various methods have been proposed of separating fibres but these have all suffered from the disadvantage that they can cause the fibres to become airborne with the obvious risk to health.

Thus, in accordance with this invention as seen from a second aspect, there is provided a method of separating fibres comprising placing the fibres on an apertured surface and agitating the surface to cause the fibres to fall through the apertures.

Preferably the surface comprises a grid having parallel-sided apertures.

Preferably the grid is selected such that the distance between opposite sides of the apertures therein is less than the length of the fibres, the distance between opposite corners of the grid being greater than the length of the fibres. We have found that this helps to ensure random orientation of the fibres as they fall through the grid.

Also in accordance with this invention, there is provided a cementitious mixture comprising the following aggregates as a percentage by weight of the cement content of the mixture:

Particle size	%
<1μm	20 - 30
9 - 300μm	50 - 60
250 - 600μm	50 - 60

Preferably the mixture comprises 2.8 - 3.8% of superplasticiser by weight of the cement content of the mixture.

Preferably the mixture comprises 50 - 60% reinforcing fibres by weight of the cement content of the mixture, preferably divided as 80 - 85% short fibres and 15 - 20% long fibres.

Preferably the ratio of water to the total of the cement and microsilica in the mixture is 0.13 - 0.23.

Preferably the mixture comprises 800-900 kg/m³ of cement.

Also in accordance with this invention, there is provided a cementitious mixture comprising the following aggregates as a percentage of weight of the cement content of the mixture:

Particle size	%
<1µm	20 - 30
9 - 300µm	17 - 27
200 - 1000µm	40 - 50
1 - 2mm	85 - 95

Preferably the mixture comprises 6.9 - 7.9% of superplasticiser by weight of the cement content of the mixture.

Preferably the mixture comprises 58 - 68% reinforcing fibres by weight of the cement content of the mixture, preferably divided as 20 - 30% long fibres and 70 - 80% short fibres.

Preferably the ratio of water to the total of the cement and microsilica in the mixture is 0.11 - 0.21.

Preferably the mixture comprises 700 - 800 kg/m³ of cement.

Embodiments of this invention will now be described by way of example only and with reference to the accompanying drawings, in which:

FIGURE 1 is a flow diagram of a method of producing a cementitious mixture in accordance with this invention; and

FIGURE 2 is a flow diagram of a method of producing an alternative embodiment of cementitious mixture in accordance with this invention.

Referring to Figure 1 of the drawings, in order to

produce a cubic metre of concrete, the following constituents are provided:

CONSTITUENTS PER CUBIC METER		KILOGRAMS
ORDINARY PORTLAND CEMENT		855
MICROSILICA (<1μm Particles)		214
QUARTZ SAND:	Particle Size	
	9-300 μm	470
	250-600 μm	470
	212-1000 μm	-
	1-2 mm	-
WATER		188
SUPERPLASTICISER*		28
BRASS-COATED STEEL FIBRES:		
	6mm	390
	13mm	78
RATIOS:		
WATER/CEMENT		0.22
WATER/BINDER (CEMENT & MICROSILICA)		0.18

* SODIUM SALTS OF SULPHONATED NAPHTHALENE FORMALDEHYDE CONDENSATE AND LIGNOSULPHONIC ACID

Initially, the coarsest constituent (250 - 600μm sand) is mixed with the finest (microsilica) for at least 2 minutes, checking that the microsilica powder is uniformly distributed.

Following this, the next coarsest constituent (9 - 300μm sand) is added and mixed for at least 2 minutes until uniformly distributed.

Following this, the next finest constituent (cement) is added and mixed for at least 2 minutes until uniformly distributed.

Following this, 25% of the shorter fibres (6mm) are placed in a coarse sieve having an aperture size of 5mm x 5mm.

The sieve is then agitated to cause the fibres to fall into the mixture. It will be appreciated that the fibres are too long to fall through the sieve without disorientation and thus helps to ensure a random orientation of the fibres in the mixture. The use of a sieve also helps to separate the fibres, thereby avoiding clumping in the mixture.

The fibres are then mixed with the mixture for at least 2 minutes before the next 25% of the fibres are added and mixed. This process is then repeated until all of the short fibres have been added.

Next, the longest fibres (13mm) are added in a similar stepwise manner using a 12mm sieve.

Now that all of the dry constituents are thoroughly mixed, the water and superplasticiser are carefully added by initially mixing two-thirds of the superplasticiser with all of the water: the remaining one-third of the superplasticiser is set aside.

One half of the water/superplasticiser mixture is then added to the mixed dry constituents and mixed for 2 - 3 minutes.

Following this, half of the remaining water/superplasticiser mixture is added and mixed for 2 - 3 minutes prior to adding a further half of the remaining mixture, which again is mixed for 2 - 3 minutes.

Finally, all of the remaining water/plasticiser mixture is added and mixed for a least 2 minutes and in any event long enough to ensure that all of the dry constituents have been mixed.

The remaining one-third of the superplasticiser is then added and mixed for approximately 3 minutes. The concrete is then cast once the superplasticiser has thoroughly been mixed in. Note that the concrete should be cast within 15 minutes of adding any superplasticiser to the mixture, in order to ensure its optimum workability.

The concrete is then cured for 28 days at 20°C.

Alternatively, a faster curing can be achieved by raising the temperature from 20°C to 90°C over 24 hours and keeping the temperature at 90°C for 7 days prior to lowering the temperature from 90°C to 20°C over 24 hours.

The water/binder ratio of the mixture is very low (0.18) due to the presence of microsilica and fine sands in place of the coarse aggregates that are commonly used. However, the lack of water does not affect the workability owing to the fine nature of the aggregates are used.

The absence of coarse particles reduces the porosity and heterogeneity of the concrete and thus the concrete is much stronger, owing to the lack of sources of local stress.

The fibres help to maximise the strength and ductility of the concrete. The long fibres (13mm) provide increased ductility, a greater pull-out strength and bridge larger cracks. A disadvantage of long fibres is that they have an adverse effect on workability. However, the shorter fibres (6mm) provide for a higher tensile strength during the early stages of loading and a more homogeneous mix owing to the fact that they are easier to mix. Thus, it will be appreciated that a compromise of long and short fibres is used.

Referring to Figure 2 of the drawings, in an alternative embodiment, two coarse sands and one fine sand is used in the ratios of 1:2:3 in addition to the microsilica and fibres. Thus, in order to produce a cubic metre of concrete, the following constituents are provided:

CONSTITUENTS PER CUBIC METER	KILOGRAMS
ORDINARY PORTLAND CEMENT	744
MICROSILICA (<1μm Particles)	178

CONSTITUENTS PER CUBIC METER	KILOGRAMS
QUARTZ SAND: Particle Size	
9-300 µm	166
250-600 µm	-
212-1000 µm	335
1-2 mm	672
WATER	149
SUPERPLASTICISER*	55
BRASS-COATED STEEL FIBRES:	
6mm	351
13mm	117
RATIOS	
WATER/CEMENT	0.20
WATER/BINDER (CEMENT & MICROSILICA)	0.16

* SODIUM SALTS OF SULPHONATED NAPHTHALENE FORMALDEHYDE CONDENSATE AND LIGNOSULPHONIC ACID

Again the concrete is mixed by mixing the dry constituents in a specified order before addition of the water and superplasticiser.

In order to maximise the density of the mix, the coarsest constituent is initially mixed with the finest, following which the next coarsest is added and mixed prior to adding the next finest: this process is repeated until all of the sand, microsilica and cement has been added.

The strength of the concrete is such that strips or beams of the concrete can be used to strengthen damaged concrete beams, for example on bridges and other structures.

Claims

1. A method of producing a cementitious mixture comprising adding granular materials having a range of particle sizes to a mixing vessel and thoroughly mixing the materials prior to adding water.

2. A method as claimed in claim 1, in which the granular materials having the finest and coarsest particle sizes are initially added to the mixing vessel and thoroughly mixed to produce a first mixture.

3. A method as claimed in claim 2, in which the first mixture is mixed for at least 2 minutes.

4. A method as claimed in claims 2 or 3, in which the granular material having the next coarsest particle size is then added to the first mixture and mixed to produce a second mixture.

5. A method as claimed in claim 4, in which the second mixture is mixed for at least 2 minutes.

6. A method as claimed in claims 4 or 5, in which the granular material having the next finest particle is then added to the aforementioned mixture and mixed to produce a third mixture.

7. A method as claimed in claim 6, in which the third mixture is mixed for at least 2 minutes.

8. A method as claimed in claims 6 or 7, in which the processes of adding the next coarsest then the next finest is repeated until all of the granular materials have been added.

9. A method as claimed in any preceding claim, in which reinforcing fibres are added to the mixing vessel prior to adding said water.

10. A method as claimed in claim 9, in which said reinforcing fibres are added to the mixing vessel following mixing of the granular materials.

11. A method as claimed in claims 9 or 10, in which fibres having different lengths are added.

12. A method as claimed in claim 11, in which the shorter fibres are added first.

13. A method as claimed in claims 11 or 12, in which the fibres are mixed with the granular material following the addition of each different length of fibre.

14. A method as claimed in any of claims 9 to 13, in which the fibres are added by placing them on an apertured surface and agitating the surface to cause the fibres to fall through the apertures.

15. A method as claimed in any preceding claim, in which the water is added to the mixture in a plurality of quantities, the mixture being mixed following the addition of each quantity of water.

16. A method as claimed in claim 15, in which the volume of water added with each quantity decreases.

17. A method as claimed in claims 15 or 16, in which the mixture is mixed for at least 2 minutes following the addition of each quantity of water.

18. A method as claimed in any preceding claim, in which

the water contains a plasticiser or superplasticiser.

19. A method as claimed in any preceding claim, in which undiluted plasticiser or superplasticiser is added following addition of the water.

20. A method of separating fibres comprising placing the fibres on an apertured surface and agitating the surface to cause the fibres to fall through the apertures.

21. A method as claimed in claim 20, in which the fibres are placed on a grid having parallel-sided apertures.

22. A method as claimed in claim 21, in which the grid is selected such that the distance between opposite sides of the apertures therein is less than the length of the fibres, the distance between opposite corners of the grid being greater than the length of the fibres.

23. A cementitious mixture comprising the following aggregates as a percentage by weight of the cement content of the mixture:

Particle size	%
<1µm	20 - 30
9 - 300µm	50 - 60
250 - 600µm	50 - 60

24. A cementitious mixture as claimed in claim 23, in which the mixture comprises 2.8 - 3.8% of superplasticiser by weight of the cement content of the mixture.

25. A cementitious mixture as claimed in claims 23 or 24, in which the mixture comprises 50 - 60% reinforcing fibres by

weight of the cement content of the mixture.

26. A cementitious mixture as claimed in claim 23, in which the reinforcing fibres comprise 80 - 85% short fibres and 15 - 20% long fibres.

27. A cementitious mixture as claimed in any of claims 23 to 26, in which the ratio of water to the total of the cement and microsilica in the mixture is 0.13 - 0.23.

28. A cementitious mixture as claimed in any of claims 23 to 27, in which the mixture comprises 800-900 kg/m³ of cement.

29. A cementitious mixture comprising the following aggregates as a percentage of weight of the cement content of the mixture:

Particle size	%
<1µm	20 - 30
9 - 300µm	17 - 27
200 - 1000µm	40 - 50
1 - 2mm	85 - 95

30. A cementitious mixture as claimed in claim 29, in which the mixture comprises 6.9 - 7.9% of superplasticiser by weight of the cement content of the mixture.

31. A cementitious mixture as claimed in claims 29 or 30, in which the mixture comprises 58 - 68% reinforcing fibres by weight of the cement content of the mixture.

32. A cementitious mixture as claimed in claim 31, in which the reinforcing fibres comprise 20 - 30% long fibres and 70 -

80% short fibres.

33. A cementitious mixture as claimed in any of claims 29 to 32, in which the ratio of water to the total of the cement and microsilica in the mixture is 0.11 - 0.21.

34. A cementitious mixture as claimed in any of claims 29 to 33, in which the mixture comprises 700 - 800 kg/m^3 of cement.

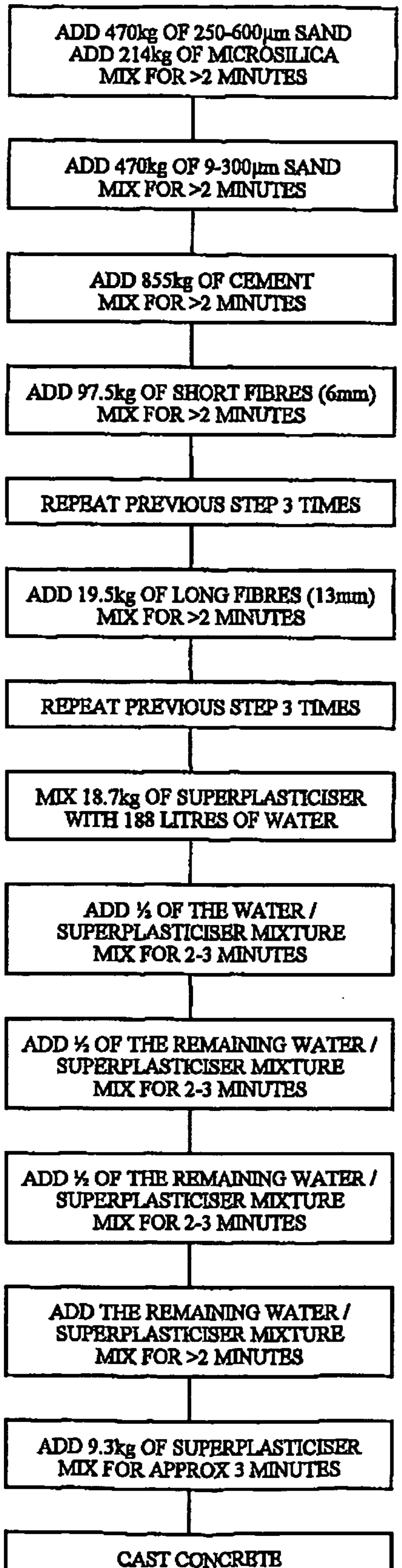
ADD 470kg OF 250-600µm SAND
ADD 214kg OF MICROSILICA
MIX FOR >2 MINUTES
ADD 470kg OF 9-300µm SAND
MIX FOR >2 MINUTES
ADD 855kg OF CEMENT
MIX FOR >2 MINUTES
ADD 97.5kg OF SHORT FIBRES (6mm)
MIX FOR >2 MINUTES
REPEAT PREVIOUS STEP 3 TIMES
ADD 19.5kg OF LONG FIBRES (13mm)
MIX FOR >2 MINUTES
REPEAT PREVIOUS STEP 3 TIMES
MIX 18.7kg OF SUPERPLASTICISER
WITH 188 LITRES OF WATER
ADD ½ OF THE WATER /
SUPERPLASTICISER MIXTURE
MIX FOR 2-3 MINUTES
ADD ½ OF THE REMAINING WATER /
SUPERPLASTICISER MIXTURE
MIX FOR 2-3 MINUTES
ADD ½ OF THE REMAINING WATER /
SUPERPLASTICISER MIXTURE
MIX FOR 2-3 MINUTES
ADD THE REMAINING WATER /
SUPERPLASTICISER MIXTURE
MIX FOR >2 MINUTES
ADD 9.3kg OF SUPERPLASTICISER
MIX FOR APPROX 3 MINUTES
CAST CONCRETE

Figure 1

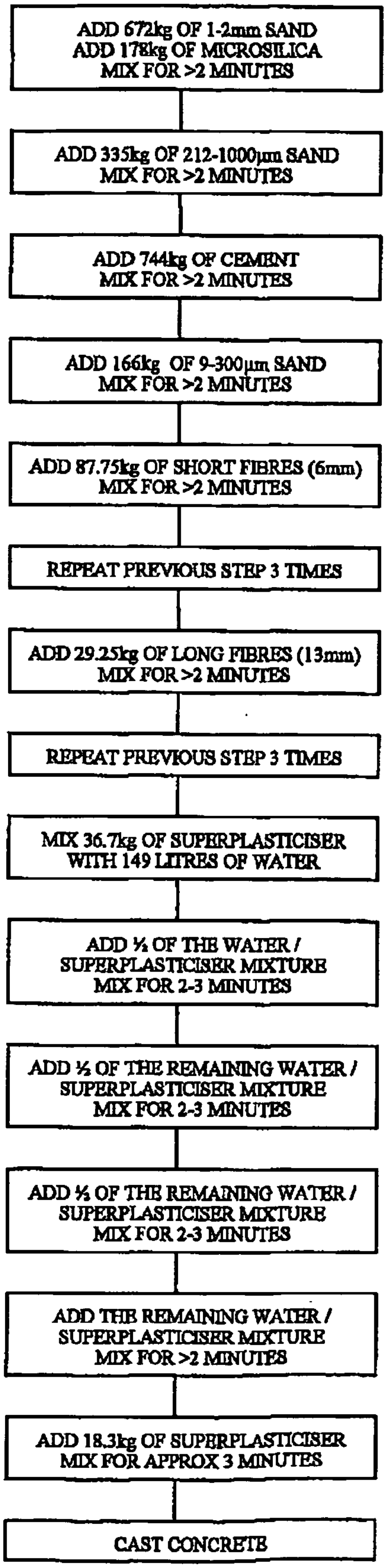
ADD 672kg OF 1-2mm SAND
ADD 178kg OF MICROSILICA
MIX FOR >2 MINUTES
ADD 335kg OF 212-1000μm SAND
MIX FOR >2 MINUTES
ADD 744kg OF CEMENT
MIX FOR >2 MINUTES
ADD 166kg OF 9-300μm SAND
MIX FOR >2 MINUTES
ADD 87.75kg OF SHORT FIBRES (6mm)
MIX FOR >2 MINUTES
REPEAT PREVIOUS STEP 3 TIMES
ADD 29.25kg OF LONG FIBRES (13mm)
MIX FOR >2 MINUTES
REPEAT PREVIOUS STEP 3 TIMES
MIX 36.7kg OF SUPERPLASTICISER
WITH 149 LITRES OF WATER
ADD ½ OF THE WATER /
SUPERPLASTICISER MIXTURE
MIX FOR 2-3 MINUTES
ADD ½ OF THE REMAINING WATER /
SUPERPLASTICISER MIXTURE
MIX FOR 2-3 MINUTES
ADD ½ OF THE REMAINING WATER /
SUPERPLASTICISER MIXTURE
MIX FOR 2-3 MINUTES
ADD THE REMAINING WATER /
SUPERPLASTICISER MIXTURE
MIX FOR >2 MINUTES
ADD 18.3kg OF SUPERPLASTICISER
MIX FOR APPROX 3 MINUTES
CAST CONCRETE

Figure 2

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 02/01774

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 C04B40/00 B28C5/00 B07B1/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 C04B B28C B28B B01F B07B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

WPI Data, PAJ, EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

* Special categories of cited documents :

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 October 2002	08/11/2002

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Daeleman, P

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Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International Application No
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
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